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JOHN LEE, Esq. LL.D. in the Chair.

Thomas William Burr, Esq., of Highbury,
was balloted for and duly elected a Fellow of the Society.

It may be as well to remind Fellows of the Society, that the pages of the *Monthly Notices* are open for the publication of all brief communications relating to astronomical science, except so far as regards planetary observations and ephemerides, the necessity for inserting which in this periodical is generally superseded by the earlier and more complete publication of intelligence of a similar kind in the *Astronomische Nachrichten*. It is manifest, however, that a few observed positions of any newly-discovered body, whether planet or comet, as well as a determination of the elements of its orbit, will serve to enhance the usefulness of the *Monthly Notices;* and it is scarcely necessary to add, that any contributions of this nature will be inserted with pleasure.

On a new Solution of the Problem of Planetary Perturbation.
By Professor Encke.

(*Extract of a Letter to the Astronomer Royal.*)

"The subject of the small planets has continued to occupy my attention so much, that I could not communicate with you until I had relieved my mind of this load of anxiety. I consider myself very fortunate on this account in being enabled, through the meritorious services of my excellent Dr. Brünnow, to transmit to you in the annexed paper the mean elements of *Flora*, with the perturbations of the same planet as produced by *Jupiter* and *Saturn*.

From the mode in which the calculation of these elements has been worked out, I am induced to entertain a confident hope that we have it now in our power to compute the perturbations of the first power of the masses for all the small planets, not even excepting *Pallas*, and that the time bestowed on the calculations is not immoderately long.

" The perturbations produced by *Jupiter* upon *Flora*, which possesses the advantage of being pretty distant from the disturbing planet, but which, on the other hand, has an excentricity of 9° and an inclination of 6°, will admit of being computed in four weeks without any immoderate haste; and even with respect to those of *Pallas*, I would pledge myself, without hesitation, to compute them for *Jupiter* and *Saturn* in the course of a winter, if nothing unusual interfered with the discharge of my ordinary duties.

" On a former occasion I had the honour of transmitting to you a copy of a paper which I communicated to the Academy, and in which I proposed an indirect method. This was not suitable to the object in view, as any one may easily convince himself, since the approximations conducted to the required result only in a few rare cases. Still the proposed method has not been useless, since it has given me the form which is most convenient for calculation, of the integral of the assigned differential equation which always reappears in the problem. By a mere simple consideration of the combinations which present themselves in this inquiry, the following solution has been obtained.

" If the differential equation has the form

$$\frac{d\,d\xi}{dt^2} + \frac{k^2}{r^{03}}\xi = \Sigma\left(a_i^{i'} \cos\left(i\,\mathrm{M} - i'\,\mathrm{M}'\right)\right),$$

in which the cosine may be exchanged for the sine, and M, M', denote the mean anomalies of the disturbed and disturbing planets, the mean motions of which are represented by μ and μ'; then, in every case, will the co-efficient of cos $(i\,\mathrm{M} - i'\,\mathrm{M}')$ or of sin $(i\,\mathrm{M} - i'\,\mathrm{M}')$ be thus determined by integration :—

Let
$$x^0 = r^0 \cos v^0 = p_0 + \Sigma\,(p_m \cos m\,\mathrm{M})$$
$$y^0 = r^0 \sin v^0 = \Sigma\,(q_m \sin m\,\mathrm{M}).$$

Also let
$$\frac{1}{r\,\mu - i'\,\mu'} - \frac{1}{s\,\mu - i'\,\mu'} = [r, s];$$

then the coefficient of cos $(i\,\mathrm{M} - i'\,\mathrm{M}')$ in the integral will have the following form :—

$$\vdots \qquad \vdots \qquad \vdots \qquad \vdots$$

$$\frac{a_{i-3}^{i'}}{k\sqrt{p}}\left\{[i-1, i-2]\frac{p_1 q_2 - p_2 q_1}{4} + [i, i-3]\frac{p_0 q_3}{2} + [i+1, i-4]\frac{p_1 q_4 + p_4 q_1}{4}\right.$$
$$\left. + [i+2, i-5]\frac{p_2 q_5 + p_5 q_2}{4} + [i+3, i-6]\frac{p_3 q_6 + p_6 q_3}{4} \ldots\ldots\right\}$$

$$+\frac{a_{i-2}^{i'}}{k\sqrt{p}}\left\{[i,i-2]\frac{p_0q_2}{2}+[i+1,i-3]\frac{p_1q_3+p_3q_1}{4}+[i+2,i-4]\frac{p_2q_4+p_4q_2}{4}\right.$$
$$\left.+[i+3,i-5]\frac{p_3q_5+p_5q_3}{4}\ \ldots\ldots\right\}$$

$$+\frac{a_{i-1}^{i'}}{k\sqrt{p}}\left\{[i,i-1]\frac{p_0q_1}{2}+[i+1,i-2]\frac{p_1q_2+p_2q_1}{4}+[i+2,i-3]\frac{p_2q_3+p_3q_2}{4}\right.$$
$$\left.+[i+3,i-4]\frac{p_3q_4+p_4q_3}{4}+[i+4,i-5]\frac{p_4q_5+p_5q_4}{4}\ \ldots\ldots\right\}$$

$$+\frac{a_{i}^{i'}}{k\sqrt{p}}\left\{[i+1,i-1]\frac{p_1q_1}{2}+[i+2,i-2]\frac{p_2q_2}{2}+[i+3,i-3]\frac{p_3q_3}{2}\right.$$
$$\left.+[i+4,i-4]\frac{p_4q_4}{4}\ \ldots\ldots\right\}$$

$$+\frac{a_{i+1}^{i'}}{k\sqrt{p}}\left\{[i+1,i]\frac{p_0q_1}{2}+[i+2,i-1]\frac{p_1q_2+p_2q_1}{4}+[i+3,i-2]\frac{p_2q_3+q_3p_2}{4}\right.$$
$$\left.+[i+4,i-3]\frac{p_3q_4+p_4q_3}{4}+[i+5,i-4]\frac{p_4q_5+p_5q_4}{4}\ \ldots\ldots\right\}$$

$$+\frac{a_{i+2}^{i'}}{k\sqrt{p}}\left\{[i+2,i]\frac{p_0q_2}{2}+[i+3,i-1]\frac{p_1q_3+p_3q_1}{4}+[i+4,i-2]\frac{p_2q_4+p_4q_2}{4}\right.$$
$$\left.+[i+5,i-3]\frac{p_3q_5+p_5q_3}{4}\ \ldots\ldots\right\}$$

$$+\frac{a_{i+3}^{i'}}{k\sqrt{p}}\left\{[i+2,i+1]\frac{p_1q_2-p_2q_1}{4}+[i+3,i]\frac{p_0q_3}{2}+[i+4,i-1]\frac{p_1q_4+p_4q_1}{4}\right.$$
$$\left.+[i+5,i-2]\frac{p_2q_5+p_5q_2}{4}+[i+6,i-3]\frac{p_3q_6+p_6q_3}{4}\ \ldots\ldots\right\}$$
$$\vdots\qquad\qquad\vdots\qquad\qquad\vdots$$

" This expression proceeds in an infinite series of terms, both in the vertical and horizontal directions. It, however, converges very quickly for any given values of i and i', so that in general, only a very small number of coefficients require to be taken into consideration in order to determine the coefficient of the integral; and since, for the sine and cosine, the expression is merely a numerical quantity, when μ and μ' are given, so is the calculation for the very small number of values of i, when i' is constant, by no means difficult.

" Dr. Brünnow has succeeded in avoiding the indirect solution by adding to the equation relative to the undisturbed orbit, viz.:

$$\tfrac{1}{2}\frac{d^2(r_0^2)}{dt^2}=k^2\left(\frac{1}{r_0}-\frac{1}{a}\right);$$

the equation for the disturbed orbit, viz.:

$$\tfrac{1}{2}\frac{d^2(r^2)}{dt^2} = k^2\left(\frac{1}{r}-\frac{1}{a}\right) + x\mathrm{X} + y\mathrm{Y} + z\mathrm{Z} + 2\int\left(\mathrm{X}\frac{dx}{dt} + \mathrm{Y}.\frac{dy}{dt} + \mathrm{Z}.\frac{dz}{dt}\right);$$

Whence, by comparison, there result the following rigorous equations:—

$$\tfrac{1}{2}\frac{d^2(r^2-r^{0\,2})}{dt^2} - \left(\frac{k^2}{r}-\frac{k^2}{r^0}\right) = x\mathrm{X} + y\mathrm{Y} + z\mathrm{Z} + 2\int(\mathrm{X}\,dx + \mathrm{Y}\,dy + \mathrm{Z}\,dz),$$

$$\frac{d^2(x-x^0)}{dt^2} + \frac{k^2x}{r^3} - \frac{k^2x^0}{r^{0\,3}} = \mathrm{X}$$

$$\frac{d^2(y-y^0)}{dt^2} + \frac{k^2y}{r^3} - \frac{k^2y^0}{r^{0\,3}} = \mathrm{Y}$$

$$\frac{d^2(z-z^0)}{dt^2} + \frac{k^2z}{r^3} - \frac{k^2z^0}{r^{0\,3}} = \mathrm{Z}.$$

Let us now suppose

$$r = r^0 + \delta r$$
$$x = x^0 + \xi$$
$$y = y^0 + \eta$$
$$z = z^0 + \zeta,$$

and let us collect together the squares and products of δr, ξ, η and ζ. We hence deduce these four equations:—

$$\frac{d\,d\,(r^0\delta r)}{dt^2} + \frac{k^2}{r^{0\,3}}(r^0\delta r) = x\mathrm{X} + y\mathrm{Y} + z\mathrm{Z} + 2\int\left(\mathrm{X}\frac{dx}{dt} + \mathrm{Y}\frac{dy}{dt} + \mathrm{Z}\frac{dz}{dt}\right)$$
$$- \tfrac{1}{2}\frac{d\,d\,(\delta r)^2}{dt^2} + \frac{k^2}{r^{0\,3}}(\delta r)^2 - \frac{k^2}{r^{0\,4}}(\delta r)^3$$

$$\frac{d\,d\,\xi}{dt^2} + \frac{k^2}{r^{0\,3}}\xi = \mathrm{X} + 3\frac{k^2x^0}{r^{0\,5}}(r^0\delta r) - 6\frac{k^2x^0}{r^{0\,7}}(r^0\delta r)^2$$
$$+ 3\frac{k^2\xi}{r^{0\,5}}(r^0\delta r)$$

$$\frac{d\,d\,\eta}{dt^2} + \frac{k^2}{r^{0\,3}}\eta = \mathrm{Y} + 3\frac{k^2y^0}{r^{0\,5}}(r^0\delta r) - 6\frac{k^2y^0}{r^{0\,7}}(r^0\delta r)^2$$
$$+ 3\frac{k^2\eta}{r^{0\,5}}(r^0\delta r)$$

$$\frac{d\,d\,\zeta}{dt^2} + \frac{k^2}{r^{0\,3}}\zeta = \mathrm{Z} + 3\frac{k^2z^0}{r^{0\,5}}(r^0\delta r) - 6\frac{k^2z^0}{r^{0\,7}}(r^0\delta r)^2$$
$$+ 3\frac{k^2\zeta}{r^{0\,5}}(r^0\delta r)$$

"The first of these equations gives $r^0\,\delta r$, and this substituted in the others gives ξ, η, ζ.

"These are essentially the first equations of the *Mécanique Céleste*."

"A second step due to Dr. Brünnow is that he has executed the numerical calculations of all the multiplications of the prescribed infinite series. This multiplication admits of being made with convenience and accuracy; and strictly affords the advantage of being far shorter than the substitutions would be if the numerical values for c were determined by multiplications executed analytically. M. Hansen had already recommended this mode of executing the numerical calculation without having further recourse to any analytical process; but it has not, so far as I know, been so generally applied in practice.

"These are the fundamental principles of the solution. Dr. Brünnow, however, has not executed the calculations absolutely in this form, but has introduced the polar co-ordinates r^0 and u^0, conformably to his method of treating the subject of special perturbations. It is quite possible, since the solution of the equations is thereby considerably simplified ($r^0\,\delta r$ being already obtained by the first equation, and consequently there only remaining δu and z to be determined), that the abbreviation is so considerable as to outweigh the disadvantages attending the somewhat less elegant symmetry of the final equations. In the meanwhile, being curious to know to what extent the expressions for ξ, η, ζ, would be found to be less convergent than δu, I have also begun the calculation by the formula here given, and hope to be soon prepared with it; should the difference be not too great, the simple mode of deducing the formulæ for ξ, η, and ζ, will always captivate me. However, this is a mere matter of taste.

"We have both found the expression for the disturbing force by the actual developement of $\frac{1}{\varrho^3}$ (ϱ being the distance between the two planets), and then by multiplication have deduced the values of the resolved forces. We thereby derive the advantage of having fewer values of ϱ^3 to calculate throughout the entire extent of the periphery. Perhaps it would be better to develope $\frac{1}{\varrho}$ into a series according to powers of M and M′, and then by two multiplications to find $\frac{1}{\varrho^3}$.

"The terms of the second order admit of being easily obtained according to this method by means of Taylor's *Theorem*, since the quantities x, y, z, are only involved, the perturbations of which are already known. But this process of calculation, which in every case is very troublesome, would be useless when the question refers to the small planets, since the elements of these bodies are not known with sufficient accuracy. Dr. Brünnow, by means of his osculating elements, has obtained pretty accurate values of the disturbing forces; and by applying the resulting

perturbations has deduced the mean elements of the planet. To me it is as good as certain that the perturbations thus calculated (the hundredths of seconds are omitted) are sufficiently accurate to be employed next year for a more exact determination of the mean elements. The terms of the first power of the masses which are here given will therefore subserve the object in view, and on a future occasion the question may be investigated, whether the terms of the second order exercise any sensible influence.

"The perturbational values are all given as they follow from the calculations. Moreover, the secular equations of the elements which might be deduced from the terms involving t (the unit of t is the Julian year) are not deduced, since for the next year the calculation in its present form is more convenient. By the way, I see that I have not made any mention of these terms in speaking of the integration of the differential equations. However, what I have said above will be quite sufficient to give you an idea of this method of computing the perturbations.

"*Berlin, April* 24, 1853."

The following are the results obtained by Dr. Brünnow relative to the planet *Flora*, to which Professor Encke alludes at the beginning of the foregoing extract:—

Mean Elements of Flora with the Perturbational Equations for Jupiter and Saturn. Calculated by Dr. Brünnow, Assistant at the Berlin Observatory, April 1853.

For the five normal places which were employed in the special perturbations, by means of the resulting perturbational equations for *Jupiter* and *Saturn*, purely elliptic mean elements were found. In this manner were obtained:—

Epoch 1848, Jan. 1·0, Mean Berlin Time.

Mean Anomaly	35 54 3·62	
Longitude of the Perihelion	32 54 28·34	Mean Equinox of the Epoch.
Long. Asc. Node	110 17 48·62	
Inclination	5 53 7·96	
Angle of Excentricity	9 0 56·29	
Mean, Dail. Sid. Mo.	1086″·330982	
Log. Sem. Maj.-axis	0·3426963	

These elements gave the mean place, and by applying the perturbational equations to each of the five normal places, the latter were thus represented:—

		Theor. — Obs. $\Delta\alpha$	$\Delta\delta$
		"	"
1848	Jan. 1·0	−0·1	+1·2
	Apr. 30·0	−0·2	−0·6
1849	May 5·5	+0·3	+1·5
1850	Sep. 18·5	−0·9	+1·9
1852	Mar. 29·0	+0·9	+1·6

The opposition for 1853 was calculated from the special perturbations. Now, if we calculate it from the purely elliptic elements, taking into account the perturbations, we have:—

		α			δ			
		°	′	"	°	′	"	
1853	July 11·5	311	49	42·0	−19	47	35·8	By Special Perturbations.
				45·3			32·1	By General ——

The perturbations of $r^0\,\delta r$ are given in seconds. They will require to be changed into units of decimals. z is the co-ordinate of the disturbed planet drawn perpendicular to the plane of the mean orbit. It is given in seconds.

δv is the correction of the true anomaly.

Perturbations of Flora by Jupiter.

	$r\,\delta r$.			δv.		
	cos		sin	cos		sin
	$+47''{\cdot}3 - 0''{\cdot}3407\,t$			$-36''{\cdot}700\,t$		
M	−12·0	$+1''{\cdot}438\,t$	$-46''{\cdot}577\,t$	$-0''{\cdot}3$	$-19''{\cdot}218\,t$	$+3''{\cdot}2\ -0''{\cdot}592\,t$
2M	−1·1	$+0''{\cdot}112\,t$	$-3''{\cdot}627\,t$	$+0\ 0''{\cdot}0 - 3''{\cdot}738\,t$		$+1''{\cdot}3\ -0''{\cdot}115\,t$
3M	0·0	$+0''{\cdot}013\,t$	$-0''{\cdot}423\,t$	$0\ 0''{\cdot}0 - 0''{\cdot}756\,t$		$+0''{\cdot}4\ -0''{\cdot}023\,t$
4M	0·0	$+0''{\cdot}002\,t$	$-0''{\cdot}058\,t$	$0\ 0''{\cdot}0 - 0''{\cdot}155\,t$		$0''{\cdot}0\ -0''{\cdot}005\,t$

	z.	
	cos	sin
	$-1''{\cdot}7 + 0''{\cdot}202\,t$	
M	$+1''{\cdot}5$	$+0''{\cdot}852\,t$ $-0''{\cdot}2\ +6''{\cdot}038\,t$
2M	$+0''{\cdot}3$	$+0''{\cdot}066\,t$ $0''{\cdot}0\ +0''{\cdot}470\,t$
3M	0·0	$0''{\cdot}0\ +0''{\cdot}055\,t$

Perturbations of Flora by Jupiter—(continued).

	$r\,\delta\,r.$		$\delta\,v.$		$z.$	
	cos	sin	cos	sin	cos	sin
	″	″	″	″	″	″
−M−M′	− 3·7	+ 4·3	− 2·1	− 2·2	+1·7	−0·7
−M′	− 49·5	+ 22·9	− 11·3	− 16·6	+4·3	−1·2
M−M′	+158·4	− 66·4	− 35·4	− 85·0	−4·4	+2·0
2M−M′	+ 23·6	− 10·4	− 7·3	− 17·3	−1·7	+0·9
3M−M′	+ 2·5	− 1·1	− 1·5	− 3·5		
−M−2M′	+ 3·6	− 3·8	+ 2·7	+ 2·6		
−2M′	+ 54·5	− 54·7	+ 14·0	+ 13·3	−3·2	+2·6
M−2M′	−100·6	+101·9	+108·2	+110·2	+6·2	−4·1
2M−2M′	−214·7	+198·8	+ 75·4	+ 80·8	+1·5	−1·3
3M−2M′	− 16·4	+ 14·8	+ 15·8	+ 17·0	−0·1	+0·1
4M−2M′	− 1·5	+ 1·3	+ 3·2	+ 3·5		
−M−3M′	+ 1·1	+ 0·2	0·0	+ 1·0		
−3M′	+ 17·9	+ 2·6	− 0·9	+ 5·9	−0·2	−0·6
M−3M′	− 21·2	+ 20·8	− 6·9	+ 42·2	+1·1	−0·8
2M−3M′	− 17·5	−112·4	− 39·8	+ 9·6	−4·3	+6·7
3M−3M′	− 15·7	+ 20·6	− 0·3	+ 5·7	−0·3	+0·3
4M−3M′	− 1·7	+ 1·8	+ 0·3	+ 1·4		
−4M′	− 1·3	+ 0·7	− 0·3	− 0·6		
M−4M′	+ 3·1	+ 3·2	− 2·0	− 4·6	−0·2	−0·4
2M−4M′	− 15·5	− 10·1	− 5·1	+ 7·3	+1·0	+1·6
3M−4M′	− 4·9	− 9·4	− 3·0	+ 2·6	0·0	+0·6
4M−4M′	− 1·1	+ 5·9	+ 1·0	+ 0·8		
5M−4M′	− 0·2	+ 0·9	+ 0·4	0·0		
3M−5M′	+ 1·8	0·0	0·0	− 0·5		
4M−5M′	− 1·2	− 1·5	− 0·4	+ 0·2		
5M−5M′	+ 0·3	+ 1·4	+ 0·3	0·0		

M denotes the mean anomaly of *Flora*, and M′ the mean anomaly of *Jupiter*.

Perturbations of Flora by Saturn.

	$r^0 \delta r$.		δv.	
	cos	sin	cos	sin
	$+1''.96 \quad +0''.0181\, t$		$1''.520\, t$	
M	$-0''.5 \quad -0''.038\, t$	$0''.0 \quad -0''.977\, t$	$0''.0 \quad -0''.403\, t$	$-0''.0 \quad +0''.013\, t$
2 M	$0\cdot0 \quad -0\cdot003\, t$	$0\cdot0 \quad -0\cdot076\, t$	$0\cdot0 \quad -0\cdot078\, t$	$0\cdot0 \quad +0\cdot003\, t$
3 M	.....	$0\cdot0 \quad -0\cdot009\, t$	$0\cdot0 \quad -0\cdot016\, t$	.....

	z.	
	cos	sin
	$+0''.028\, t$	
M	$0''.0 \quad -0''.116\, t$	$0''.0 \quad -0''.106\, t$
2 M	$0\cdot0 \quad -0\cdot009\, t$	$0\cdot0 \quad -0\cdot008\, t$

	$r^0 \delta r$.		δv.		z.	
	cos	sin	cos	sin	cos	sin
	$''$	$''$	$''$	$''$	$''$	$''$
$-M-M'$,	$+0''.1$	$-0''.3$				
M',	$-0''.7$	$-2''.1$	$+1''.3$	$+0''.3$		
$M-M'$,	$+3''.3$	$+7''.8$	$+3''.6$	$-1''.5$	$0''.0$	$+0''.1$
$2M-M'$,	$+0''.3$	$+0''.8$	$+0''.7$	$-0''.3$		
$3M-M'$,	.....	.....	$+0''.1$	$0''.0$		
$-2M'$,	$-1''.5$	$+3''.0$	$-0''.4$	$-0''.1$	$+0''.1$	$0''.0$
$M-2M'$,	$+5''.4$	$-10''.0$	$-5''.3$	$-3''.0$	$+0''.4$	$-0''.1$
$2M-2M'$,	$+2''.7$	$-5''.8$	$-2''.4$	$-1''.2$		
$3M-2M'$,	$+0''.2$	$-0''.4$	$-0''.5$	$-0''.3$		
$4M-2M'$,	.....	.....	$-0''.1$	$0''.0$		
$-3M'$,	$0''.0$	$+0''.5$	$-0''.1$	$0''.0$		
$M-3M'$,	$+0''.2$	$-1''.5$	$-1''.0$	$-0''.1$		
$2M-3M'$,	$-0''.4$	$-1''.2$	$-0''.5$	$+0''.1$		
$3M-3M'$,	$+0''.4$	$-0''.1$	$-0''.1$	$-0''.1$		

M denotes the mean anomaly of *Flora*, and M′, the mean anomaly of *Saturn*. The unit of time is the Julian year of $365\frac{1}{4}$ days.

Extract of a Letter from Sig. Secchi to Captain R. H. Manners, R. N.

" On the occasion of the last observations which I have made of the solar spots, I have read again what Mr. Grant states, in his *History of Physical Astronomy*, respecting Dr. Wilson's theory of the spots. I think Dr. Wilson is right when he says that the penumbra is made by the slopes of the collapse of luminous matter tending to fill the holes and close up the gaps in the solar atmosphere. The objections made to him that the penumbra is too sharply terminated at the limit from the brilliant part, I think, does not more subsist, after my observations made in the way suggested by Mr. Dawes. I have always seen the structure of the penumbra radiate towards the centre of the nuclei, and, what is very singular, that each radius, or rather streamlet, which composes the penumbra, is equally brilliant as the rest of the luminous body. The penumbra seems to me made by a mixture of streamlets of luminous matter with the dark intervals of the black ground which constitutes the nuclei. So we have an explanation of an almost invariable fact which has been a puzzle to every theory, namely, that the outline which separates the nucleus from the penumbra is similar to the outline which separates the penumbra from the luminous part. As I intend to develope this subject, after some more observations will be made; so, for the present, I will conclude by simply stating, that I do not mean to enter into the theory of the *production* of the spots, but only into that part which belongs to the *description* of them, and so I dare say Dr. Wilson's theory is the best. Sir J. Herschel's views respecting a circulation analogous to our trade-winds being the cause of the solar spots, seems to me to acquire new interest from the fact that the solar equator is hotter than the polar regions.

" The comet of the 6th of March has not been seen more since the 11th of April; and on the 5th I saw a star of the 11th magnitude through it. I would send you some observations of the new planet, but want of space prevents me. I will only add that I am very glad that Mr. Lassell also observed the different colour at the two sides of the black ring of *Saturn*, which I had seen several times last year (see our *Memoirs* for 1851, p. 36).* If the great refractor is ready next year, we shall be able to make some better observations, and to tread the path made by Mr. Lassell.

" *Rome, April* 28, 1853."

* This volume has not yet been received at the apartments of the Society.—R. G.

Letter from the Rev. W. R. Dawes to the Editor.

" Some suggestions have been made, and experiments tried, with the hope of imitating some of the phenomena of a total solar eclipse, and thus obtaining a sight of the red projections from the edge of the sun. It is, however, evident, that though the image of the sun itself may be completely and exactly concealed by some contrivance in the eye-piece, or permitted to pass through an aperture into a dark chamber, while the equatoreal movement is regulated precisely to apparent solar time, yet there will remain a great and, I fear, insurmountable obstacle, in the *luminosity of the earth's atmosphere* enlightened by the sun's rays. This difficulty appears to have been overlooked. If a telescope furnished with an eye-piece having a very small field, or half the field covered, be directed to the sky close to the border of the sun, the sun itself being just excluded, the glare is far too powerful to be endured by the eye without the interposition of a pretty deep tint of darkening glass. Such, at least, has been the case under the most favourable circumstances of clear and deep blue sky, during which I have been able to try the experiment.

" In the autumn of 1851, after my return from observing the total solar eclipse in Sweden, it occurred to me that the best chance of obtaining a sight of these phenomena might be afforded by taking advantage of that state of sky, lovely indeed, but too rarely seen in this country, where detached and sharply-defined clouds are slowly moving over the deep blue surface of the heavens. On two or three such occasions, the clock-movement of my equatoreal having been carefully regulated, I watched the passing of well-defined clouds over the sun, which certainly seemed to produce a rather darker tint of sky in the immediate vicinity of the sun's edge than any artificial contrivance in the eye-piece. Yet the advantage gained was not such as to give the slightest hope of success.

" If it is at all possible to render these extremely delicate phenomena visible by artificial means, it will probably be accomplished by erecting a suitable instrument on the top of one of the highest accessible mountains in a fine climate, like that of Oroomiah in Persia, as described by Mr. Stoddard, where the smaller density of the atmosphere and its great dryness exceedingly diminish its illumination by the sun's rays. A telescope of very moderate size might answer the purpose, if equatoreally mounted and driven accurately by clock-work.

" *Wateringbury, May* 6, 1853."

We are requested to state, that the observations on suspected variable light in the letter of the Rev. T. W. Webb, at page 186 of the last number, refer to the star β *Corvi*, not *Coronæ*, as there erroneously stated.

On the Orbit of the First Comet of 1850.

By R. C. Carrington, Esq.

The readers of the *Astronomische Nachrichten* will recollect that in No. 803 Mr. Sonntag, assistant at the Altona Observatory, published an orbit of Dr. Petersen's third Comet, which he had very elaborately deduced from a careful discussion of all the European and American Observations, about 400 in number. Mr. Sonntag's conclusion was, that the orbit was sensibly parabolic, the numerical deviation resulting from his equations of condition being many times less than its probable error. It was hardly to be expected, after this, that further observation and discussion would materially modify his result, yet such I have found to be the case, and the result is instructive; for though in ordinary cases it would excite no surprise that an excentricity should be elicited by an increase of the arc of observation, Mr. Sonntag's result appeared too exact and too well based to countenance the expectation.

The comet's excentricity was not, however, its only feature of interest. At the bottom of page 155 of vol. x. of the *Monthly Notices* will be seen the paragraph, "Mr. Gauss is even of opinion that it is not *proved* that a comet must, after having passed the perihelion, move in the same orbit as before." I cannot say that I apprehend the exact idea contained in this sentence, although I can read it in more ways than one; yet I think my calculation will afford a satisfactory answer to it. The orbit of this comet after perihelion fits perfectly to that before. This, although not a general proof, is a particular instance.

In residual phenomena, attributable to physical causes extraneous to gravitation, this comet offers "no case for a jury," the final uncompensated differences of the normals being of a magnitude attributable to observation.

My calculation is, strictly speaking, a combination of Mr. Sonntag's. I adopted at once his eight normal positions, not thinking a recomputation of the European observations would repay the time it would take: to those I was enabled to add two other normals, drawn from the very excellent observations made by Mr. Maclear himself at the Cape of Good Hope, Mr. Sheepshanks having kindly allowed me to take a private copy. For the whole period of visibility the perturbations of the six innermost planets were calculated and applied according to the new co-ordinate method of Professor Encke. In this part of the work I derived assistance, which I am happy here to acknowledge, from the annotated translation published by the Astronomer Royal in the *Nautical Almanac* for 1856. In this paper I pass at once to my result, as I have sent a fuller account to Dr. Petersen for insertion in the *Nachrichten*.

The elements represent the instantaneous orbit of May 12, 1850 (at Greenwich, noon):

T	.....	1850, July 23·565169	Berlin Mean Time.
$\varpi - N$	.....	180° 31′ 36″·74	Mean Eq^{x}. 1850·0.
N	.....	92 53 27·84	
I	.....	68 11 23·56	
e	.....	0·9988519	
q	.....	1·0814488	Motion direct.

leaving the following uncompensated normal differences :—

		$\Delta\alpha \cdot \cos\delta$	$\Delta\delta$	
1.	May 10·0	+5″·88	−1″·88	
2.	21·0	−3·05	−0·86	
3.	30·5	+0·01	−0·93	
4.	June 7·5	−0·57	+0·67	
5.	21·0	−0·19	+1·67	
6.	July 2·5	−0·07	−0·70	
7.	12·0	+0·47	−0·54	
8.	21·0	−1·06	+1·01	
9.	Sept. 15·0	+1·28	−0·48	The Cape Normals.
10.	Oct. 5·0	−0·36	−0·65	

The period corresponding to the excentricity given above being somewhat short of 29,000 years.

Letter from M. Yvon Villarceau to the Astronomer Royal.

"I have the honour to transmit to you along with this letter a copy of a Memoir which I have just presented to the Academy of Sciences, upon the double star η *Coronæ*. I shall be gratified if you should find it worthy of being presented to the Astronomical Society.*

"Allow me to avail myself of this circumstance to give you some explanations upon a subject of controversy, which appears to have excited the attention of the Astronomical Society.

"In a memoir upon the comet of D'Arrest, I expressed the opinion that the observations of that body, made with the heliometer of Königsberg on the occasion of its last apparition, might be more precise than those which have been obtained elsewhere during the same period. M. Otto Struve appears to conclude from this remark, that, in general, I prefer heliometer observations of comets to those made with a refractor as powerful as that of Cambridge, and he declares that he does not concur with me in adopting this preference. The circumstance which induces him to reject the heliometer in its application to observations of comets consists in

* An abstract of M. Villarceau's Memoir will be found at p. 229.

the diminution of the brightness of the images, arising from the duplication of the object-glass.

"I suspect that my excellent friend, M. Otto Struve, has not rightly understood the meaning of my proposition, or, probably, the fault is attributable to myself. In a letter referring to subjects of a rather varied kind, and in which I communicated to him the results to which a discussion of the observations of D'Arrest's comet had conducted me, I did not insist sufficiently upon the point which has become the subject of controversy.

"With the view of fixing the meaning of my proposition, I divide into two classes the modes of procedure employed in observations of comets.

"First, the telescope is fixed in a position such that the comet and the star of comparison ought to present themselves successively in the field of view by the effect of the diurnal motion. With respect to the right ascension, the observation consists in estimating the instants of the passage of the comet and the star across fixed wires, insomuch that the difference of right ascension is based upon the appreciation of instantaneous phenomena.

"Secondly, the telescope is rendered movable in position by means of a clock movement, the star is fixed in the field of view, and the comet ought to be visible in the field at the same time. The observation, according to this method, is made in the same way as when the companion of a double star is observed: or, again, the comet may be considered to be connected by way of triangulation with several small stars visible at the same time in the field. This method, which has been already employed with success, especially by M. Otto Struve, differs from the former inasmuch as the measure of time no longer enters into the determination of the difference of right ascension. The bisection of the image of the comet may be made with the greatest facility by means of an apparatus fitted with wires: the observer may operate at his ease: the instantaneous phenomenon which offers difficulties of observation in the other method does not present itself here: and the time merely serves to fix the date of observation.

"I have discussed, in my Memoir, the different circumstances, according to which the sensibility of the organ of vision plays an important part in the determination of the right ascensions of very faint comets observed by the first method: there are cases in which the right ascensions ought, in general, to fall short of their true values. The optical power of the instrument cannot diminish this inconvenience, except when the comet has ceased to have a certain degree of brightness; but at the moment when it is about to disappear in large instruments, the inconveniences to which I am referring, ought to manifest themselves as well as in instruments of merely moderate power. In the latter, they will manifest themselves several weeks or months earlier, and the comet soon ceases to be observable, while large instruments allow of the observations being continued for a longer time. The errors of right ascension of very feeble comets which have their source in the manner in

which the retina is affected during the *passage* of a comet behind a wire, ought, according to my opinion, to disappear entirely if we employ the second method, in which the comet is bisected by a wire, and *remains* in that state during an interval of time, which is enormously longer than that of a passage.

"My opinion, then, is, that better results will be obtained by making use of the second method of observation; that which is, in fact, practised by M. Otto Struve himself. Now, it happens that, in the case of the comet of D'Arrest, the only instrument which has been applied in this way is the heliometer of Königsberg. It is not, however, the heliometer which I extol in so far as regards the comet, but rather the method above referred to. With respect to the heliometer in particular, it may be inferred that if the images are sufficiently bright to be observable without much difficulty, the results may be better than those which would be obtained by employing the first method even with refractors of sufficient power. Now, in the case of the comet of D'Arrest, the heliometer observations will be found to be as concordant as the others; the only difference being, that the observer was compelled to abandon his observations eight days earlier than Mr. Challis at Cambridge.

"If, now, we were to apply the second method, making use of a refracting telescope of the same power as the Northumberland refractor, the observations would unquestionably be more precise than those obtainable by means of refractors of the same dimensions, but fitted with divided object-glasses, since the intensities of the images are in the ratio of 2 to 1. Thus, let it be well understood, it is not the heliometer which I prefer, but the second method of observing comets.

"I regret much that I am unable to lay before you the grounds of the reasoning employed in my Memoir; possibly you might find that I have somewhat exaggerated the inconveniencies of the first method of observation. There is much to be said upon this subject, and, unfortunately, the arguments do not admit of being reduced to figures, which would tend very much to simplify the difficulties.

"Excuse, I pray you, this long digression, which I should not have thought of placing before your eyes, as too uninstructive, if I had not been led to it by the reading of the *Monthly Notices*.

"*Paris, April* 28, 1853."

On the Mechanical Imitation of Precession. By the Rev. Professor Powell, F.R.S., &c.

The actual mechanical exhibition of the composition of rotatory motion giving the physical explanation of the Precession of the Equinoxes has been attempted by more than one contrivance.

In the *Astronomical Notices*, vol. i. p. 43, appears a description of a machine of this kind by Mr. Atkinson, but so brief that it is difficult to collect what the principle of it was. It is also under-

stood that another instrument was constructed by the Astronomer Royal; but of this it does not appear that any description has been published.

In the present instance, before the author was aware of either of these contrivances, he had constructed one which he believes exhibits the essential mechanical principle with greater simplicity than any previously devised.

It consists merely of a bar (loaded at its ends) capable of rotating freely about one end of an axis, which itself can turn about a point in its length, near the end carrying the bar, upon an horizontal axis capable of moving in azimuth round a vertical pillar. At the lower end of the first axis is a weight, which *rather more* than counterpoises the upper part; and when there is no rotation in the bar, simply brings the first axis down into a vertical position.

If this axis be held horizontally or obliquely, and a rotatory motion be given to the bar about it, on letting the axis go, the weight will no longer bring it down, nor alter its inclination at all, but will cause the whole to turn in azimuth, in a direction opposite to that of rotation.

Note on the Small Star near α Canis Minoris.

By Isaac Fletcher, Esq.

"In the Bedford Catalogue Captain Smyth* notes that the star *α Canis Minoris* is accompanied by a small companion of the eighth magnitude. The following is the result of the Captain's measures:—

1833·81 Pos. 85°·0; Dist. 145″.

"In 1848, Mr. Bond, of the Cambridge U.S. Observatory, announced that the small star was '*missing*.' In 1850 I saw and measured the position of the companion with ease, and estimated it as of the ninth magnitude. My measures gave this result:—

1850·17 Position 84° 19′.

"During the spring of this year I have looked most carefully for this small star with my 6-foot achromatic; but I have never obtained a trace of its existence.

"This star is undoubtedly a variable one of the most interesting description, and as such I beg to recommend it to those observers whose attention is directed to this class of phenomena.

"*Tarn Bank, Cockermouth*, 1853, *May* 5."

* Those Fellows of the Society who are not already cognizant of the fact, will be gratified to learn, that since Mr. Fletcher's note was written, the distinguished officer, to whose well-known work on astronomy allusion is here made, has been promoted to the rank of rear-admiral.

Discovery of a New Planet. By M. Luther.

(*Extract of a Letter from Professor Argelander to the Rev. R. Sheepshanks.**)

"I have great pleasure in announcing to you the discovery of a new planet on the 5th of May, by M. Luther, at Bilk. Unfavourable weather prevented a complete confirmation of the discovery before the 14th of the same month: hence the late announcement. M. Luther has only sent the following positions:

	Bilk M.T.	R.A.	Decl.
	h m	° ′	° ′
May 5	13	207 40	−10 15
14	11 52	206 3	9 57

To which may be added the following observations by M. Schönfeld:

	Bonn M.T.	R.A.	Decl.
	h m s	° ′ ″	° ′ ″
May 15	12 0 41·6	205 53 41	−9 55 46·5

"The planet is only equal to a star of the 10·11th magnitude: consequently, it cannot be observed longer in our telescopes. The Northumberland refractor, however, might show it long enough to obtain elements of sufficient accuracy to prevent its being lost. Would you have the kindness to request Professor Challis to undertake the charge of the friendly stranger?

"*Bonn, May* 16, 1853."

M. Luther states, in a communication to the *Astronomische Nachrichten*, announcing his discovery of the planet, that he hopes to be enabled to follow its track by the aid of the excellent charts of Messrs. Bishop and Hind.

Micrometrical Measurements of the Double Stars, ε Boötis, γ Virginis, 44 Boötis, ζ Boötis, and ζ Herculis, made at the Observatory, Whitehaven. By J. F. Miller, Esq. F.R.S.

ε Boötis.

Magnitudes, 3, 7, 5. Colours, yellow and sea-green.

Ref. No.	Position.	Weight.	Obs.	Distance.	Weight.	Obs.†	Epoch.
	° ′			″			
98	321 58	3	8	2·862	2	9	1852·279
124	321 1	4	8	2·839	3	8	1853·230
137	320 39	2	9	2·736	1	3	·304
Means	321 15	9	25	2·829	6	20	1852·937

"124. With this power the small star is obviously sea-green; though, with 250, it was pronounced to be bright blue. There is no certain evidence of change in this star, either in position or in distance.

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* In consequence of Mr. Sheepshanks having been recently absent from this country, on the occasion of a short visit to the Continent, he did not receive M. Argelander's letter till a day or two ago, when the present number of the *Monthly Notices* had been already made up, and was just about being printed off. It only remained, therefore, to extract the more important parts, and substitute them for other communications, the publication of which might be conveniently delayed till the issue of the next number. This circumstance accounts for a part of the communication being inserted here, and another part at page 238.

† "The distances throughout represent double measures, consequently each set really consists of sixteen observations."

γ Virginis.

Magnitudes, 3·2, 3·5. Both stars white.

Ref. No.	Position.	Weight.	Obs.	Distance.	Weight.	Obs.	Epoch.
	° ′			″			
123	175 7	4	8	3·114	4	8	1853·227
125	75 11	4	8	3·067	4	8	·241
126	175 15	4	8	3·167	4	8	·241
29	174 44	4	8	3·041	4	8	·243
130	174 58	4	9	3·274	1	8	·298
136	174 33	1	7	...	...	...	·304
139	174 20	2	8	...	...	...	·312
Means	174 54	23	56	3·108	17	40	1853·266
Means	175 17	11	48	3·122	7	24	1852·262
Means	175 54	7	15	3·040	3	8	1851·475

The upper star is still the brightest.

44 *Boötis.*

Magnitudes, 5, 5½. Both stars white.

Ref. No.	Position.	Weight.	Obs.	Distance.	Weight.	Obs.	Epoch.
	° ′			″			
127	240 25	4	8	4·291	4	8	1853·241
128	240 25	4	8	4·349	3	8	·241
134	239 20	3	8	4·361	2	9	·304
135	239 36	2	7	4·367	2	8	·304
140	240 52	4	8	4·370	4	8	·315
Means	240 14	17	39	4·349	15	41	1853·281

"The collected measures show that the stars have been gradually opening since the distance was first determined by Struve, in 1819.

	Position.	Distance.	Epoch.
	°	″	
Herschel I.	60·10	...	1781·62
Struve	228·0	1·50	1819·43
Do.	233·65	2·555	1829·20
Dawes	235·65	3·280	1833·39
Do. (Bishop's Cat.)	235·60	3·841	1842·39
Hind (Do.).....	237·99	4·261	1847·09
Miller	240·23	4·349	1853·28

ζ Boötis.

Magnitudes, 4·5, 4·5. Both stars white.

Ref. No.	Position.	Weight.	Obs.	Distance.	Weight.	Obs.	Epoch.
	° ′			″			
133	127 38	4	8	1·2 est.	...	...	1853·298
138	127 32	2	8	1·1 est.	...	...	·312
141	126 33	4	8	1·202	4	8	·315
143	127 25	4	8	1·181	4	8	·317
Means	127 14	14	32	1·191	8	16	1853·310

"A comparison of prior measures with the above appears to indicate the fixity of this pair.

	Position.	Distance.	Epoch.
	°	″	
Herschel I.	131·98	1·00	1796·66
Struve	129·28	1·19	1830·47
Dawes	128·28	1·32	1832·47
Do. (Bishop's Cat.)	127·03	...	1841·57
Do. (Do.)	127·03	1·039	1843·32
Miller	127·23	1·191	1853·31

"I cannot say that I have ever seen this star fairly divided before the present spring.

ζ Herculis.

Magnitudes, 3, 7. Colours, A yellow; B purple.

Ref. No.	Position.	Weight.	Obs.	Distance.	Weight.	Obs.	Epoch.
	° ′			″			
132	77 28	1	8	1·5 est.	1	...	1853·298
142	78 49	4	8	1·454	3	8	·315
144	78 38	4	8	1·334	4	8	·317
146	79 40	2	8	1·422	1	8	·324
147	78 8	2	9	...	...	...	·378
149	78 25	3	8	...	...	...	·380
Means	78 38	16	49	1·402	9	24	1853·335
Means	84 4	4	16	...	...	...	1852·769
Means	89 9	6	16	...	...	...	1851·650

"This elegant binary star, with the short period of thirty-five years, moves with such rapidity in its orbit, that the angular motion of the acolyte is quite appreciable, year by year.

"The epochal results indicate an increase in the distance of late years; and I believe the interval between the components is now not far short of $1\frac{1}{2}$ seconds.

	Position.	Distance.	Epoch.
	°	″	
Herschel I.	69·30	...	1782·55
Struve	23·40	0·910	1826·63
Do.	196·99	1·094	1835·45
Do.	168·65	1·030	1838·44
Dawes (Bishop's Cat.)	150·67	1·230	1840·66
Do. (Do.)	129·89	1·298	1843·58
Struve	119·06	1·248	1845·27
Dawes	112·23	...	1846·83
Miller	89·15	...	1851·650
Do.	84·06	...	1852·769
Do.	78·63	1·402	1853·335

"The companion of ζ *Herculis* has been pretty steadily visible in my telescope during the last three years.

"Between the 24th of March and the end of April we were favoured with an uninterrupted continuance of the finest astronomical weather I almost ever remember, and it was during this period that most of the above results were obtained. The eye-piece employed was a new lens of admirable workmanship,—power 500, made by Mr. Simms, with which systems of the 3d and 4th magnitude (under illumination) presented perfect discs, with scarcely a trace of rings. Indeed, nothing could exceed the beauty and sharpness of the stellar definition with this eye-piece; and I prefer it to any lower power, when the atmosphere is at all tolerably steady.

"During the magnificent weather which has prevailed since the commencement of May, the astral definition has been so deplorable that I have only obtained three sets of positions in as many weeks, with the apparent advantage of an almost continuously bright and unclouded sky. Since the beginning of the month the air has been in an exceedingly dry state, the dew-point ranging from 12° to 22°·5 below the temperature of the air.* To the very unequal distribution of moisture over the upper and lower strata of the atmosphere the twirling, moulding, and blotted appearance of the stars is, no doubt, to be attributed.

"*Observatory, Whitehaven, May* 24, 1853."

On the probable Errors of the Eye and the Ear in Transit Observations. By the Rev. T. R. Robinson, D.D., President of the Royal Irish Academy.

With respect to the usual mode of recording transit observations, and the invention recently introduced at American observatories for accomplishing the same object by means of electricity, the author remarks, that *the two systems not merely employ different senses to co-operate with sight, but that the sight itself is used in two different ways.* In the "Electric Register" the eye catches the moment when the star crosses a wire, and the touch is to synchronise with it in giving a signal. In the common modes the ear counts the clock's beats; the eye notes the distances of the star from the wire at the beats which precede and follow its passage, and thus the mind estimates the fraction of the second from the relative position of three points; all existing in memory alone, when that estimation is made.

"The error, which may be caused by uncertainty in catching the precise part of the beat which shall be taken for the origin of the second, is the same for every star (at least, if we suppose the

* "To day (24th), at 3 p. m., the difference between the temperature of the air and of evaporation was 16°·3; and the complement of the dew-point, 24°·5!!"

clock equally audible in every position of the telescope, and the observer able to observe in all with equal convenience, for personal discomfort will interfere with the attention), that arising from uncertainty in estimating the star's place will vary inversely as the cosine of its declination.

"But there is yet another, arising from the actual displacement of the star's image, by irregular changes in the refractive density of the atmosphere: the effect will, as the preceding, be inversely as the cosine of declination, but also directly as the magnitude of these changes. This depends, in the first place, on the heterogeneity of the air as to heat and moisture; and, in the second, on the quantity of disturbed medium through which the line of sight passes. The former scarcely admits of expression in terms of our present meteorological data, and we must be content to assume for it an average value. In respect to the other, as the disturbance takes place chiefly within a small distance of the earth's surface, it will easily be seen that its amount is as the secant of zenith distance. If, then, we denote by u the probable error of the ear, by y that of the eye, and by z the atmospheric tremor at the zenith, we have, by the theory of these errors, for a star whose declination is δ,

$$\varepsilon^2 = u^2 + \frac{y^2}{\cos^2\delta} + \frac{z^2}{\cos^2\delta \,.\, \cos^2(l-\delta)}.$$

Hence, if we select three stars, properly differing in zenith distance, we can determine the three errors, u, y, z. By a process of this kind, executed in the year 1830, the author found, from observations of his own made at Armagh:

$$u = \pm 0^s{\cdot}0445; \qquad y = +0^s{\cdot}0619; \qquad z = \pm 0^s{\cdot}0381.$$

In the author's case, therefore, the ear could estimate the twenty-third part of a second, and its precision was to that of the eye as 7 : 5.

A second examination was instituted several years afterwards, certain alterations having been made in consequence of the first one.

"As the value of y was not very much less than the whole ε that I had obtained with the former eye-piece, notwithstanding its low power, a new one was obtained from the late Mr. Dollond, of 240, and very good. Nine lines were inserted by Mr. Grubb, finer and more uniform than the previous seven; the clock, whose arc of repose had been four times that of escape, had its weight changed from 4 lb. to 1·75; and a multitude of trees and shrubs were removed from the south of the transit-room, as their evaporation was a manifest cause of unsteadiness. All these, except the alteration of the clock, tended to lessen the error; that improved the rate, but it made the beat less audible in high winds, and therefore would increase u. In this instance, stars all of the first magnitude were selected. The results were,

$$u = \pm 0^s{\cdot}0732; \qquad y = \pm 0^s{\cdot}0554; \qquad z = 0^s{\cdot}0049.$$

The error of hearing is considerably increased, that of sight a little lessened; but the tremor is only a seventh part of its original amount."

"It is evident that the same equations apply to the new mode of observation, if u represent the error of touch; and it is to be hoped that a similar discussion of its probable errors may be soon instituted, for there are a number of inquiries which must be answered before its superiority will be fully appreciated. Independent of the possibility, that the means employed to close and break the voltaic circuit may disturb the clock's pendulum, and that the promptness of the register may vary with the intensity of the battery, it is certain that in the obedience of the finger to the will there must be a personal equation; and it is possible that this, unlike that of the ordinary transit observer, may be variable. For any regular succession it will probably be insensible, as I infer from some observations given by Mr. Mallet, in the Report of his valuable experiments on the propagation of earthquake waves, p. 306. Starting a chronograph at a given beat of a clock, and stopping it at another, he gives the differences from the mean; whence I compute ϵ, for himself $= \pm$ 0^s·0449, and for his son $\pm$ 0^s·0592. Each of these involves two errors of ear and two of finger, so that the measure of one of each is 0^s·0318 and 0^s·0419. These come so near to my u, that any error of touch is scarcely possible: the case is, however, a special one, and may be compared to the counting seconds without a clock, which a practised observer will do with surprising accuracy. Phenomena not regularly recurring could scarcely be taken so accurately.

"The error of sight will, for the reason already given, be less in the case of stars; as to the sun and moon, it is more doubtful. In the transit they have larger probable errors than the stars. For the sun I obtained, in 1830, the first limb $\pm$ 0^s·116, the second $\pm$ 0^s·087; the moon gave $\pm$ 0^s·149; while stars observed at the same hour, and near the same parallel, had but $\pm$ 0^s·097. This greater uncertainty arises from the strong contrast between the bright and dark surfaces whose boundary we take; and a similar one may be expected in attempting to note the precise instant of its passage.

"As to tremor, it will act here precisely as in transit observations; and it may, moreover, perhaps nullify one of the proposed advantages, that of making many observations in a few seconds. The undulations of the air are twofold,—those of short period, which cause the flutter that produces z, and those of much longer duration, which, without blurring the star, displace it, and sometimes cause the pole star, after crossing the wire, to go back, and after ten or even fifteen seconds make a second transit. In the present mode, such waves affect only a single wire, and may be neutralised by others; but in the other they would vitiate the whole set."

Note VI. on Double Stars. By M. Yvon Villarceau.

η Coronæ Borealis.

"The double stars whose elements may be regarded as approximately ascertained are four in number, viz. ξ *Ursæ Majoris*, *p Ophiuchi*, ζ *Herculis*, and *η Coronæ*. This number will be further reduced to three, if the double solution which I have announced in the *Comptes Rendus*, tome xxviii. p. 411,* should hold good till the present time. The object of this Note is to fix the one of the two solutions of the orbit of *η Coronæ*, which ought definitively to be adopted."

"It will be recollected that the ambiguity which I encountered arose from the circumstance that the two components of the system have so close a physical resemblance to each other, that it is impossible to distinguish the one from the other except by their relative positions. This distinction, which is possible when the positions compared differ slightly from each other, or are separated by a short interval of time, ceases to be so when they refer to distant epochs which do not embrace any intermediate observation. This difficulty presents itself in the case of two observations of Sir William Herschel made in 1781 and 1802, and distant from each other twenty-one years. An equal interval of time separates the latter from the epoch of 1823, whence commences a series of observations, extending without interruption down to the present day. The question arises, Ought the observations of Sir William Herschel to be employed in the same way as they have been originally presented, or ought they to be *reversed*, that is to say, modified to the extent of 180°? The condition of representing them by the same system of elements as the modern observations can alone decide this alternative."

M. Villarceau remarks, that by preserving the position of 1802 in his former researches, he was obliged to reverse that of 1781, and was hence conducted to an orbit characterised by a revolution of about sixty-six years, which no one had hitherto suspected. On the other hand, reversing the observation of 1802, and preserving that of 1781, he obtained an orbit of about forty-three years. This is the orbit which had been already announced by astronomers, and which is to be found in the greater number of the works which treat of the subject of double stars. Although a minute discussion of the physical circumstances of the two observations of Sir William Herschel suggested probabilities in favour of the orbit of sixty-six years, still, as a comparison of the two orbits did not assign any serious reasons for preferring either orbit, it was deemed expedient to refer to another epoch the question to be decided between the

* See also *Additions à la Connaissance des Temps pour* 1852.

two solutions. The year 1853 was fixed upon for this purpose; but it was announced by M. Villarceau that the two orbits might possibly be separated before that time, if the optical power of the great refractor of Pulkowa admitted of the observations being continued, notwithstanding the close approach of the component stars.

"The observations," says the author, "have been, in fact, continued till this time, and the interest excited by the subject has induced Messrs. Lassell and Hartnup to make observations in England, which they have had the kindness to communicate to me. Mr. Dawes has also been kind enough to transmit to me a series of unpublished observations, extending for *η Coronæ* down to 1849 inclusive. This circumstance enables me to present already the results which I have arrived at in so far as regards the choice between the two orbits. I have also availed myself of the new observations to correct the elements of the definitive orbit, the occasion for executing which process I pointed out at the conclusion of my first communication."

"At the first glance it was easy to see that the series of observations made since the year 1847 could not agree with the orbit of 43 years. I accordingly applied myself to the correction of the elements of the orbit of 66 years. There now occurred a difficulty which the insufficiency of the data had prevented me from encountering in my former researches, and which had already presented itself in my investigation of the orbit of *ζ Herculis*, but in a form less pronounced; I refer to the employment of distances in determining the orbits of stars so close to each other. Determining the elements of *ζ Herculis* by the aid of angles of position alone, I succeeded in representing these angles satisfactorily enough, but the distances exhibited systematic errors. Employing simultaneously the angles of position and the distances, the latter were better represented, but systematic errors appeared in the angles of position."

"In my new researches upon *η Coronæ* an attempt to correct the elements, by employing simultaneously the angles of position and the distances, has conducted me to results which leave strongly-pronounced and inadmissible errors in the comparison of the angles of position. Taking into consideration the great precision of the measures of the angles of position, I then resolved to employ solely the latter, and to reserve the measures of distance for the determination of the semi-axis major alone. On this point I may remark, that five measures of distance executed by M. W. Struve from 1826 to 1835 exceed 0″·7; while seventeen other measures, executed subsequently by the same astronomer and by M. Otto Struve and M. Mädler, are comprised between 0″·6 and 0″·4. When any other elements beside the semi-axis major are to be deduced from the measures of distance, the results depend especially *upon the variations of distance.* Now it is evident that the variations of distance comprised between 0″·6 and 0″·4 are quite comparable with the errors that may affect measures of such delicacy. With respect to the other five distances comprised between 0″·7 and

1″·15, the employment of their variations also presents difficulties to which I shall presently refer. I have consequently been induced by these considerations to employ exclusively the angles of position in the correction of all the elements except the semi-axis major."

M. Villarceau has determined the semi-axis major of the orbit from the measures of distance executed by M. W. Struve, M. Otto Struve, and M. Mädler. With respect to the distances of M. W. Struve, which are less than 0″·8, and which, as in all other similar cases, were obtained by mere estimation, M. Villarceau has applied to them a small correction, the necessity of which was suggested to M. Struve by experiments on the distances of artificial stars, and originally announced by him in his *Mensuræ Micrometricæ*. M. Villarceau has also found it necessary to apply a similar correction to the distances comprised between 0″·4 and 0″·6 which were observed by M. Otto Struve, at Pulkowa; and also to two observations of distance executed by M. Mädler, at Dorpat.

The observations of angles of position which have been employed in correcting the elements of the orbit of *η Coronæ*, are in number 37, comprising all those with which the author was acquainted. The equations of condition have been treated by the method of least squares. The following are the new elements deduced :—

Passage of the Perihelion	1779·338 ; 1846·647	
Mean Annual Motion	5°·3484	
Angle of Excentricity	23° 51′·0	
Longitude of the Ascending Node	9° 52′·3	Counted from the Meridian of 1850.
Longitude of the Perihelion	194° 51′·9	
Inclination	±59° 18′·6	
Semi-axis Major	1″·2015	

Whence

	yrs.
Period of Revolution	67·309
Excentricity	0·40433

These elements differ only in a slight degree from those given in the *Connaissance des Temps* for 1852. The greatest angular difference, that relative to the position of the node, is 5° 31′; the time of revolution has been augmented by about a year; and the date of the passage of the perihelion by about three months.

The following numbers exhibit the results of a comparison of the corrected elements with the totality of the observations. In the column of observers, the names of the two Herschels are denoted by W. H. and J. H.; those of the Struves by W. S. and O. S.; the affix J. H. and S. indicates the joint observation of Sir John Herschel and Sir James South. The names of Messrs. Dawes, Hartnup, Lassell, and Mädler, are denoted by the letters D, H, L, and M.*

* The Table of M. Villarceau is more complete than that given in the text; but we are compelled from want of space to omit several of the columns.—Ed.

Date.	Observer.	Observed Angle of Position − Cal. Angle. Dihedral.	In Arc.	Cor. Distance − Cal. Dist.
		° ′	″	″
1781·7	W. H.	−0 12	−0·002	—
1802·7	id.	+1 5	+0·028	—
1823·3	J.H.&S.	−1 33	−0·038	—
1826·8	W. S.	+0 24	+0·008	−0·055
1829·6	id.	+0 19	+0·006	−0·061
1830·3	J. H.	−1 11	−0·020	−0·151
1831·4	D.	+1 10	+0·018	—
1831·4	J. H.	+2 12	+0·034	—
1831·6	W. S.	−0 38	−0·010	+0·019
1832·5	J. H.	+1 8	+0·016	—
1232·6	D.	+0 45	+0·011	—
1832·8	W. S.	−0 14	−0·003	+0·027
1833·3	J. H.	+1 53	+0·025	—
1833·4	D.	+2 36	+0·034	—
1835·4	W. S.	−2 23	−0·026	+0·157
1836·5	id.	+0 39	+0·006	+0·089
1837·5	W.&O.S.	−4 7	−0·038	−0·025
1838·4	id.	−5 17	−0·048	−0·028
1839·8	O. S.	−3 45	−0·035	+0·144
1840·5	O. S.	−1 46	−0·017	+0·073
1841·4	M.	+0 25	+0·004	+0·010
1841·5	O. S.	+0 31	+0·005	+0·041
1842·2	M.	+0 1	0·000	−0·006
1843·3	O. S.	−2 44	−0·031	+0·003
1845·6	W.&O.S.	−2 2	−0·025	−0·051
1846·6	O. S.	+1 45	+0·022	−0·070
1846·9	D.	+2 41	+0·033	—
1847·6	O. S.	+2 8	+0·026	−0·093
1848·0	D.	+1 41	+0·020	−0·025
1848·7	O. S.	−0 22	−0·004	−0·054
1849·4	D.	+3 45	+0·041	+0·073
1849·7	O. S.	−1 54	−0·020	+0·007
1850·5	id.	−4 3	−0·040	−0·017
1851·4	H.	+1 7	+0·010	—
1851·4	L.	+3 9	+0·029	—
1851·6	O. S.	−5 0	−0·045	+0·009
1852·6	id.	+4 41	+0·040	+0·032

"We now proceed," says the author, "to explain the mode in which we have determined the semi-axis major. The other elements obtained by means of the angles of position alone enable us to calculate the different values of the ratio of the distance to this element. Let ϱ' denote this ratio, A the semi-axis major, A ϱ the distance observed and corrected conformably to the indications of M. Struve, we have then for each observation of distance an equation of the form $\varrho = \varrho' A$.

"Treating by the method of least squares the totality of the equations founded on the observations of M. W. Struve, and submitting to a similar process the observations of M. Otto Struve and M. Mädler, we obtain the three following equations:—

By 8 Observations of M. W. Struve.....	4″·3217 = 3·5770 A;	whence	A = 1″·2082
12	— of M. O. Struve.....	3·7067 = 3·1063 A;	—	A = 1·1933
2	— of M. Mädler	0·5908 = 0·4903 A;	—	A = 1·205
By the totality of 22 Observations.....	8·6192 = 7·1736 A;	—	A = 1·2015

"The greatest deviation of these three determinations from the final result is only 0″·008. So close an agreement tends to justify the application which we have made to the observations of MM. Otto Struve and Mädler, of the corrections which were legitimately applicable only to those of the elder Struve."

"The two measures of distance obtained by Mr. Dawes were omitted, because, in consequence of the feeble optical power of his

instruments compared with those of Dorpat and Pulkowa, the measures of very small distances did not seem to be readily comparable with those made in Russia. Still the errors $-0''{\cdot}025$ and $+0''{\cdot}073$ deduced from a value of the semi-axis major obtained without employing the observations of Mr. Dawes, show that the observations of that distinguished astronomer are not so far from being comparable with those of MM. Struve as one would at first have supposed. The semi-axis major which the two measures of Mr. Dawes give is $1''{\cdot}241$,—a value which differs only by $0''{\cdot}040$ from the definitive value. Moreover, it is to be borne in mind that this result being deduced from quantities which are almost a half less than the result obtained, the influence of errors of observation is almost doubled."

"It will be seen from the foregoing table that the greatest residual error of the angle of position reduced to arc does not exceed $0''{\cdot}048$. Their totality gives for the probable error of an angle of position expressed in the same way $0''{\cdot}0188$. Now M. Struve has established that the probable error of the mean of three observations of angle of position reduced to arc varies from $0''{\cdot}018$ to $0''{\cdot}028$ for the distances comprised between $0''{\cdot}70$ and $1''{\cdot}48$. The result above given accords very well with the experimental determinations of M. Struve.

"There appear, in the foregoing table, traces of a systematic error between the epochs 1837 and 1840. It is to be remarked, however, that this interval comprises *a passage of the apparent perihelion;* besides, there are no other observations than those of MM. Struve. Again, from 1846 to 1848 there appear several errors affected with the same sign, but which, however, are very small. Finally, the rather sensible errors of the two last observations may be attributed to the close approach of the two stars; for the companion is advancing towards the apparent perihelion which it ought to have passed in 1853·377, the distance being reduced at that epoch to $0''{\cdot}484$."

"It now remains to show how the orbit of forty-three years satisfies the observations. We shall confine ourselves to a comparison of the two last observations of M. Otto Struve with the elements (second solution) published in the *Connaissance des Temps* for 1852. The result of this comparison is:—

Date.	Obs. Angl.—Cal. Angl.	Obs. Dist.—Cal. Dist.	Cor. Dist.—Cal. Dist.
	°	″	″
1851·56	− 104·71	− 0·035	+ 0·083
1852·62	− 91·30	− 0·213	− 0·093

"A more approximate value of the deviations of the two orbits may be obtained, in so far as the angles of position are concerned, by eliminating from the observations of M. Otto Struve the errors indicated by the comparison exhibited above. In this manner there results:—

	°	′	
1851·56;	− 99	7	
1852·62;	− 96	11	
or about	− 97	5	for the beginning of 1852.

"Now, a discordance of this magnitude cannot be made to disappear by a slight change in the elements. We are then authorised to reject the orbit of forty-three years of revolution, and to consider the orbit of sixty-seven years as being that which the companion of η *Coronæ* really describes.

"The revolution of 67·309 years does not appear to me to be susceptible of being sensibly modified by ulterior observations, seeing that the position corresponding to the ancient observation of Sir William Herschel has been attained and surpassed within the last few years. The period of revolution is henceforward affected only by an uncertainty, at the utmost equal to the time during which an angle of position would be described corresponding to the algebraic difference of the mean error of the modern observations and that of Sir William Herschel. It will be easily seen that this uncertainty cannot exceed a year. Now, the number 66·257 years already satisfies the totality of the observations anterior to 1848. It is plain, therefore, that the true time of revolution, if it exceed 67·309 years, cannot deviate from it more than a fraction of a year.

"I may add, in conclusion, that having applied to the observations of MM. Struve alone, the method presented in my third Memoir upon double stars, without subjecting them to a correction relative to the distances, I have obtained immediately an orbit, still somewhat indeterminate, it is true, but in which the time of revolution was found to be 69·3 years. Thus, without having recourse to the ancient observations of Sir William Herschel, the series of observations of MM. Struve suffices already to give an approximate idea of the orbit of η *Coronæ*."

Instructions and Suggestions for Mariners observing the total Solar Eclipse of Nov. 30, 1853.*

(Appended to a Letter from M. Jul. Schmidt, of the Observatory of Bonn, to Lieut. Maury, U.S.N., and communicated by Admiral W. H. Smyth.)

Every mariner navigating the Pacific Ocean in the neighbourhood of the line of central eclipse is requested (if possible to make observations) to direct his attention to the following points :—

I.—Observations with the Telescope during the total Eclipse.

1. Note the duration of total darkness in seconds of sidereal or mean time.

2. Note the time when, before the beginning of the eclipse, *the corona* (white ring round the dark moon) makes its appearance.

3. Note the time when, in the reappearance of the sun's light, the corona disappears.

4. Observe, if the corona is circular, if it has rays; and if so, are they perpendicular to the moon's limb?

* This eclipse will be total along a certain belt of the Pacific Ocean between the coast of Peru and the Sandwich Islands.

5. Note the diameter of the corona in parts of the moon's diameter.

6. Note the colour of corona.

7. Observe how many *red flames*, prominences, or protuberances, are visible.

8. On what points (counting eastward from the highest point) on the moon's periphery are the prominences situated?

9. Estimate the extent in length and breadth, if one or more prominences, either in minutes, of space or in parts of the moon's diameter.

10. Do the prominences on the east side of the moon decrease and disappear?

11. Do those on the west side increase, and disappear with the reappearance of the sun's light?

12. Does there appear at the beginning and end of total darkness a *red limb* (a series of small and combined red flames)?

13. Give a sketch as accurate as possible of the forms and relative situations of the prominency.

14. Note the colour or tint of the red flames.

15. Are the prominences red at the commencement of their visibility, or do they redden later?

16. What other appearances in the vicinity of the red flames in the corona?

17. Are there in the nearest vicinity of the sun's limb to the prominences *solar spots?*

18. Note the colour of the moon's disc.

II.—Observations without a Telescope during the whole Eclipse.

1. Note the changes in the colour of the sky during the increase and decrease of the eclipse, as well as the totality.

2. Note the variations of the temperature of the atmosphere.

3. Note the variation in the direction of the wind.

4. Observe the dew.

5. Observe the behaviour of sea-birds in the vicinity of the vessel.

6. Observe the colour of the sea, before, during, and after the total darkness.

7. How many stars, and of what magnitude, besides the most splendid, are visible during the totality?

8. Are the prominences visible to the naked eye?

9. What is the colour and form of the corona as seen with the naked eye?

It must be left to the direction of the navigator which of the above observations he, in accordance with the means in his power, will make himself, and which he will distribute among his subordinates.

Lastly, it is desirable for each observer to note—

a. The longitude and latitude in which the observations have been made.

b. Whether the telescope inverts or not, as well as its magnifying power.

J. F. Julius Schmidt,
Astronomer.

Royal Observatory at Bonn, Prussia,
Feb. 19, 1853.

Tables du Mouvement apparent du Soleil, deduites de la Comparaison de la Théorie avec les Observations faites depuis 1750 *jusqu'à nos Jours.* Par M. Le Verrier.*

M. Le Verrier having, about two years since, executed a complete theory of the perturbations by which the apparent motion of the sun is affected, was subsequently induced to institute a comparison between his theory and an extensive series of observations of the sun. These researches have resulted in his construction of new solar tables, forming the subject of his present communication to the Academy of Sciences. The most remarkable part of this communication is the announcement of an irregularity in the motion of the solar perigee, which it seems impossible to account for by the existing theory of the sun's motion.

M. Le Verrier proposed to establish his investigation of the correction of the elements of the solar orbit upon the observations of the sun made by Bradley at Greenwich, about the middle of the last century, and the modern Greenwich observations. The results thus deduced might be verified by comparing them with a series of observations made about the middle of the included interval.

He selected for the earlier materials of his investigation 719 observations of the sun made by Bradley between the years 1750 and 1762. The modern data consisted of 516 observations, made under the superintendence of the present Astronomer Royal between the years 1840 and 1850. These observations were reduced by the aid of the fundamental catalogue of stars recently constructed by M. Le Verrier.

Having determined the secular variations of the excentricity and the perigee by comparing their values as derived from the two sets of observations, and taking into account the included interval of time, extending to ninety years, M. Le Verrier obtained results which appeared to him incompatible with any admissible change in the masses of the disturbing planets.

With the view of throwing light upon the subject, he had recourse to intermediate observations. For this purpose he chose 631 observations of the sun, made at Greenwich, Paris, and Palermo, during the years 1801–2–3–4. A rigorous discussion of these data served only to increase his perplexity. The correction of the ex-

* *Comptes Rendus*, tome xxxvi. p. 349.

centricity did not indeed offer any difficulty, being equal to the mean of the corrections found for the years 1755 and 1845, as ought necessarily to be the case, if the correction varied according to the first power of the time. With respect to the correction of the perigee, however, the case was quite different. Instead of being equal to the mean of the values found for 1755 and 1845, it was very considerably larger than either. Thus it appeared that the secular variation of the solar perigee, as deduced from the observations, besides being incompatible with the admitted values of the masses of the disturbing planets, presented the additional difficulty of not being simply proportional to the time.

A further appeal to observation seemed to offer the only means of arriving at some definitive solution of this question. M. Le Verrier accordingly had recourse to 241 observations, made at Greenwich during the years 1783–85, and to 1037 observations made at Greenwich, Paris, and Königsberg, during the years 1814–18. The number of observations of the sun which formed the groundwork of his researches consequently now amounted to 3144. By a comprehensive and searching discussion of the totality of these data, he finally arrived at the conclusion that the variable correction of the solar perigee might be represented by the following formula:

$$-7''{\cdot}9 + 0''{\cdot}535\,t + 29''{\cdot}8 \sin (5^{\circ}{\cdot}4\,t + 207^{\circ}{\cdot}85)$$

in which t expresses the number of years, counting from the beginning of 1850. The following table exhibits a comparison of the results derived from this formula, with the corresponding results of observation:

Date.	Correction of the Solar Perigee deduced from the Observations.	Calculated Correction.	Calculation —Observation.
	″	″	″
1753·3	−39·4	−38·5	+0·9
1759·0	−25·3	−27·7	−2·4
1784·4	−56·4	−59·3	−2·9
1801·5	−62·3	−58·1	+4·2
1803·5	−46·5	−53·3	−6·8
1815·3	−20·9	−16·1	+4·8
1817·7	− 8·1	− 8·6	−0·5
1842·8	− 2·7	− 6·0	−3·3
1848·2	−24·4	−18·2	+6·2

From the close agreement which subsists between the observed and calculated corrections of the solar perigee, as exhibited in the foregoing table, M. Le Verrier considers himself fully authorised in announcing that, independently of the movement, the cause of which is known to us, *the solar perigee is subject to an oscillation whose amplitude is 60″ and whose period is 66⅔ years.* He further concludes, that, besides this periodic oscillation, the solar perigee is subject to a secular variation of 53½″ which is not produced by the action of known masses. The excentricity of the solar orbit offered

indications of a similar variation, but of a magnitude much less pronounced.

Without professing to announce a positive opinion on the subject, M. Le Verrier seems disposed to think that the combined action of the minor planets may not impossibly be the cause of these irregularities.

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*Elements of Themis.** By MM. Forster and Krüger.

(*Communicated by Professor Argelander to the Rev. R. Sheepshanks.*)

The following elements of the planet *Themis* were calculated by MM. Krüger and Forster, from two observations made at Naples on the 6th and 13th of April, and two observations made at Bonn on the 27th of April and the 10th of May.

Epoch 1853, May 10·43140, Berlin M.T.

	°	′	″
M =	341	52	26·8
π	213	32	44·2
Ω	32	26	35·3
i	0	53	46·8
φ	14	21	14·2
Log a			0·561038
Log μ			2·708450

A comparison of these elements with the observations gives the following results:—

		Theor. — Obs. $\Delta\lambda$	Δl
		″	″
April	6	−0·4	+31·6
	13	−0·2	− 0·9
	27	+1·0	− 0·8
May	10	+0·1	−18·8

Accompanying these elements was an ephemeris of the planet, calculated by M. Krüger, and extending from May 20 to June 17. Any Fellow of the Society may obtain a copy of this ephemeris, by applying at the Apartments of the Society.

* This name has been selected for the planet by Sig. Secchi, at the invitation of the discoverer, M. De Gasparis. It is the same name which M. De Gasparis originally intended to confer on the planet *Massalia*.

ERRATA.

Vol. XIII. Page 87, line 1 from top, *for* 1852 *read* 1853.
— — 156, — 22 — *for* Stoddart *read* Stoddard.

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